WHAT IS CLAIMED IS:

1. In a fiber-optic transmission system including at least one transmission link having a length, optical loss, dispersion, a sign of dispersion and a cut-off wavelength, the invention comprising a single optical element to compensate for the dispersion and to balance the optical loss, the optical element including:

an input port for receiving an optical signal having a signal wavelength;

a distributed gain medium having an optical loss and connected to the input port to amplify the optical signal;

a pumping mechanism having a pump wavelength for generating a pumping light to pump the distributed gain medium at a pumping level sufficiently high so that the optical signal experiences a net gain to compensate for the optical losses of the transmission link and the gain medium; and

an output port for outputting the amplified optical signal.

2. The invention as claimed in claim 1 wherein the distributed gain medium is gain fiber having a length, dispersion and a sign of dispersion.

3. The invention as claimed in claim 2 wherein the gain fiber has a dispersion-length product substantially equal in magnitude to a dispersion-length product of the at least one transmission link but of opposite sign.

4. The invention as claimed in claim 2 wherein the gain fiber has a cut-off wavelength shorter than the pump wavelength so that the gain fiber is single spatial mode for both the pump wavelength and the signal wavelength.

5. The invention as claimed in claim 2 wherein the optical signal is amplified in open loop fashion.

6. The invention as claimed in claim 5 wherein the gain fiber is pumped bi-directionally by the pumping mechanism.

7. The invention as claimed in claim 5 wherein the gain fiber has two separate segments and wherein the pumping mechanism pumps the two segments in a counter-propagating fashion.

8. The invention as claimed in claim 7 further comprising an isolator to connect the two segments.

9. The invention as claimed in claim 7 further comprising a gain equalization element to connect the two segments.

10. The invention as claimed in claim 7 further comprising an optical add/drop multiplexer to connect the two segments.

11. The invention as claimed in claim 10 further comprising a gain equalization element connected to the optical add/drop multiplexer.

12. In a fiber-optic transmission system including at least one transmission link having a length, optical loss, dispersion, a sign of dispersion and a cut-off wavelength, the invention comprising:

an input port for receiving an optical signal having a signal wavelength;

a gain fiber having an optical loss and connected to the input port to amplify the optical signal;

a pumping mechanism having a pump wavelength for generating a pumping light to pump the gain fiber at a pumping level sufficiently high so that the optical signal experiences a net gain to compensate for the optical losses of the transmission link and the gain fiber;

an output port for outputting the amplified optical signal; and

a pump shunt coupled to the input and output ports to shunt the pumping mechanism wherein the gain fiber has separate first and second segments separated by the input and output ports and wherein the pumping mechanism pumps the first segment in a counter-propagating fashion and then pumps the second segment to deplete power of the pumping mechanism.

13. The invention as claimed in claim 12 further comprising an isolator to connect the first and second segments.

14. The invention as claimed in claim 12 further comprising a gain equalization element to connect the first and second segments.

15. The invention as claimed in claim 12 further comprising an optical add/drop multiplexer to connect the first and second segments.

16. The invention as claimed in claim 12 wherein the second segment is pumped bi-directionally by the pumping mechanism.

17. The invention as claimed in claim 2 wherein the optical signal is amplified in a closed loop fashion.

18. The invention as claimed in claim 2 wherein the gain fiber at least partially defines a broadband cavity which is pumped bi-directionally by the pumping mechanism.

19. The invention as claimed in claim 18 wherein the gain fiber is a Raman gain fiber and wherein the broadband cavity is a Sagnac Raman cavity.

20. The invention as claimed in claim 2 wherein the distributed gain medium includes a circular loop cavity and wherein the gain fiber has two separate segments which are pumped in a counter-propagating fashion by the pumping mechanism.

21. The invention as claimed in claim 1 wherein the transmission line is a multi-wavelength transmission line having non-uniform gain over different wavelength channels and further comprising a second optical element for evening the non-uniform gain over the different wavelength channels.

22. The invention as claimed in claim 21 wherein the second optical element includes at least one stage of Mach-Zehnder interferometers.

23. The invention as claimed in claim 21 wherein the distributed gain mechanism is a gain fiber having two separate segments and wherein the second optical element connects the two segments.

24. In a fiber-optic transmission system which operates in a violet band between 1430 and 1530 nm and includes at least one transmission link having a length, optical loss, dispersion, a sign of dispersion and a cut-off wavelength and a dispersion shifted fiber (DSF) having at least one fiber non-linearity effect and a zero dispersion wavelength, the invention comprising:

an input port for receiving an optical signal having a signal wavelength;

a distributed gain medium having an optical loss and connected to the input port to amplify the optical signal;

a pumping mechanism having a pump wavelength for generating a pumping light to pump the distributed gain medium at a pumping level sufficiently high so that the optical signal experiences a net gain in the violet band to compensate for the optical losses of the transmission link and the gain medium and sufficiently far from the zero dispersion wavelength to avoid the at least one fiber non-linearity effect in the at least one link; and

an output port for outputting the amplified optical signal.

25. The invention as claimed in claim 24 wherein the gain fiber is a standard dispersion fiber.

26. The invention as claimed in claim 24 wherein the at least one fiber non-linearity is four-wave mixing.

27. The invention as claimed in claim 24 wherein the at least one fiber non-linearity is modulation instability.

28. The invention as claimed in claim 24 wherein the DSF has a plurality of fiber non-linearities including four-wave mixing and modulation instability and wherein the single optical element avoids the plurality of fiber non-linearities.

29. The invention as claimed in claim 24 wherein the at least one transmission link has non-uniform gain over different wavelength channels and further comprising a second optical element connected to the single optical element for evening the non-uniform gain over the different wavelength channels.

30. The invention as claimed in claim 29 wherein the second optical element includes at least one stage of Mach-Zehnder interferometers.

31. The invention as claimed in claim 24 wherein the gain fiber is a dispersion compensating fiber selected so that accumulated dispersion is balanced at a substantial middle of the violet band.

32. In a fiber-optic multi-band system including a multi-wavelength transmission line, a method for minimizing gain tilt within at least one existing band of wavelengths as additional bands of wavelengths are added, the method comprising:

adding a substantially equal number of additional bands both above and below the at least one existing band of wavelengths to obtain shorter and longer wavelength bands to minimize energy change in the at least one existing band of wavelengths; and

amplifying the shorter and longer wavelength bands so that each of the shorter and longer wavelength bands has a gain.

33. The method as claimed in claim 32 wherein the step of amplifying the shorter wavelength bands is accomplished with discrete or distributed Raman amplifiers.

34. The method as claimed in claim 32 wherein the step of amplifying the longer wavelength bands is accomplished with Erbium-doped fiber amplifiers wherein the gain in at least one of the shorter wavelength bands is greater than the gain in at least one of the longer wavelength bands.

35. The method as claimed in claim 32 wherein the gain in at least one of the shorter wavelength bands is greater than the gain in at least one of the longer wavelength bands.

36. The method as claimed in claim 32 wherein the step of amplifying the shorter wavelength bands is done in a distributed fashion.

37. In a fiber-optic multi-band transmission system including a multi-wave transmission line, the apparatus comprising:

a plurality of band pumps for pumping different bands of the transmission line to obtain amplification wherein band pumps for different bands interact non-linearly by exchanging energy; and

means for orthogonalizing adjacent band pumps to minimize the non-linear interaction.

38. The apparatus as claimed in claim 37 wherein alternate band pumps are spatially dispersed to minimize interaction between band pumps for the different bands.

39. The apparatus as claimed in claim 37 wherein alternate band pumps are cross-polarized to minimize interaction between band pumps for the different bands.

40. The apparatus as claimed in claim 37 wherein the plurality of band pumps define a purely distributed system of distributed Raman amplifiers.

41. The apparatus as claimed in claim 37 wherein the plurality of band pumps define a hybrid system of discrete and distributed amplifiers.

42. The apparatus as claimed in claim 37 wherein the plurality of band pumps include discrete laser diodes for pumping the transmission line.

43. The apparatus as claimed in claim 37 wherein the plurality of band pumps include a Raman oscillator for pumping the transmission line.

44. The invention as claimed in claim 1 wherein the pumping mechanism includes at least one laser diode.

45. The invention as claimed in claim 1 wherein the pumping mechanism includes a Raman oscillator.

46. The invention as claimed in claim 1 wherein the pumping mechanism includes a Raman wavelength shifter.

47. The invention as claimed in claim 2 wherein the gain fiber exhibits Raman scattering when pumped by the pumping mechanism.

48. The invention as claimed in claim 20 wherein the distributed gain medium includes chirped bragg gratings.

49. The invention as claimed in claim 37 wherein the amplification is distributed Raman amplification and wherein the energy is Raman energy.

50. The invention as claimed in claim 24 wherein the distributed gain medium utilizes Raman gain.